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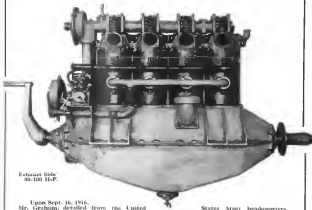


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# AVIATION AND AERONAUTICAL ENGINEERING

OCTOBER 1, 1916

VOL. I. NO. 5

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## Object of Investigation

With the recent great increase in size of airplanes, it has become increasingly difficult to provide control surfaces (ailerons, elevators, rudders) of adequate strength and stiffness without the use of elaborate exterior bracing adding to load resistance and the number of parts whose failure may be disastrous. Very large control surfaces, if load supported, require an effort beyond the muscular strength of the pilot unless the control mechanism be geared down at the expense of

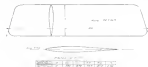


FIG. 1. LOCATION OF CENTER OF GRAVITY AND CENTER OF LIFT FOR A CONTROL SURFACE

efficiency of movement. The standard method of fitting trailing surfaces and elevator flaps involves "balancing," as usually employed on rubber, as an ineffectual means of relief. It would be of advantage to have a control surface which could be given great thickness (to provide structural strength) without material penalty in the aerodynamic properties of the used thin, nearly flat, control surface. The center of pressure action must be such that the surface may act in a "balanced" manner.



FIG. 2. BALANCE CURVE SURFACE NO. 1 AS TESTED AT THE NATIONAL PHYSICAL LABORATORY

## Profiles Discussed

The Curtiss Aeroplane Company have proposed a double cambered surface of great thickness. Fig. 3 A model 20 by 5 inches of this surface was sent by this company to be tested in the wind tunnel of the Massachusetts Institute of Technology and the results are now published with their permission. It will be seen that the maximum thickness of this profile is

<sup>1</sup> Bulletin No. 10 Institut Aeronautique de l'Université de Paris, 1914, p. 101.  
<sup>2</sup> Ibid., p. 101.  
<sup>3</sup> Ibid., p. 101.  
<sup>4</sup> Ibid., p. 101.  
<sup>5</sup> Ibid., p. 101.

about 3 per cent of the chord, about double usual position. Angle span is adjusted thus for sectional rise and span.

To compare with this profile, we have selected the thin surface of Fig. 2, which has been tested full size at St. Cyr and in the wind tunnel at Ames and at Teddington.<sup>1</sup> We cut drawings of the dampers between the three sets of experiments, we will reproduce the results obtained at Teddington as a model of nearly the same size as our Curtiss profile, but at nearly the same wind velocity and with a wind tunnel and balance identical with our own. Under these conditions the results for the two profiles are comparable, and possible errors of method being common to both sets of experiments may be ignored for purposes of comparison.

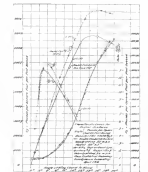


FIG. 3. CURTISS PROFILE CURVES FOR CONTROL SURFACE

It will be noted that the St. Cyr profile is only matched as thick as the Curtiss and is uncambered, giving the effect of camber on one side only. In general, a control surface is to be operated on either side of its neutral position and ought to give equal effects for positive and negative angles. It should, therefore, be symmetrical. It might be suggested that we should compare with well known data for flat plates with square edges. There, however, the edges are so blunt that the resistance at small angles of incidence is enormous. Also such profiles are not used on modern airplanes.

## Aerodynamical Properties

For the Curtiss profile the angle of zero lift is 0°. In Fig. 4 the curves of the aerodynamical coefficients, lift and resistance (drag), for the double cambered profile are plotted on angle of median line to wind as abscissa. The correspond-

ing curves as reported for the St. Cyr profile have been shifted 1° to the right in order to make the curves of lift coefficient pass through 0°. Due to lack of symmetry the lift on the St. Cyr surface is zero when the lower chord makes an angle of -1° with the wind. (See X, P. 1, test.)

The curves of resistance coefficients are closely identical for the two wings and for small angles the lift coefficients are not greatly different. At large angles, the St. Cyr profile shows from 10 to 20 per cent greater lift than we get for the Curtiss. On the other hand, if the plot were extended to negative

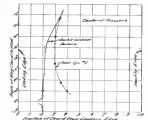


FIG. 4. CURTISS PROFILE CURVES

angles, the lift of the Curtiss profile would be equal and opposite while the lift of the other would be reduced due to its central camber being useless at negative angles. The greater lift at large positive angles for the St. Cyr profile is not in itself a real advantage.

The maximum lift for each profile is created at about 16°, which angle should be the maximum control movement allowed the pilot in the design. The mean, or resistance, is about 10 for the two profiles at an angle between 5° and 4°.

The greatest interest attaches to the maximum resistance and the resistance at very small angles, too, evidently, the airplane in good weather will be flown with its control surfaces very near the neutral position. Excessive resistance at the neutral position (angle of no lift) is a waste of power. The curves of Fig. 4 show that the thick Curtiss profile has no zero resistance than the other.

In conclusion, it appears that the extra thickness required for rigidity is obtained in the Curtiss profile without sacrifice in aerodynamical properties.

## Center of Pressure

The location of the center of pressure for the two profiles is shown in Fig. 4. The Curtiss profile will have about 3 of chord from leading edge would be almost perfectly "balanced," and a pilot could move it 10° or more without sensible effect. If control were abandoned, the surface would oscillate with return to a neutral position. Similarly, the St. Cyr profile with zero rise 26 of the chord from the leading edge could be used for a "balanced" control surface.

## Variation with Speed of Test

Opportunity was taken to repeat the test on the Curtiss

profile at 10, 20 and 40 miles per hour. The results plotted as a polar diagram (after Eiffel) are shown on Fig. 5. The discrepancies are not great. At small angles or for values of the lift coefficient below  $K_L = .0003$ , the resistance coefficient  $K_R$  is progressively decreasing as the speed is raised. This is undoubtedly due to the fact that at such small angles of incidence the resistance is largely skin friction which does not vary so rapidly as the square of the speed.

For values of  $K_L$  above .0005, we approach the "hatched" point or critical angle for the wing. Here the flow is turbulent and measurement difficult. It is possible that the wind of the tunnel may have a certain degree of turbulence which is more pronounced at some speeds than at others. The turbulence of the wind should have its greatest effect upon the lift of an airplane wing near the critical angle. The discrepancy between the curves near the critical angle is of the order of 5 per cent and is probably inherent in wind tunnel experiments. It is inevitable that an average value be taken in this region.

The very low resistance shown for the double cambered wing

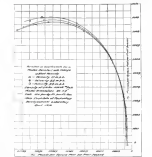


FIG. 5. VARIATION IN COEFFICIENTS FOR A MOON AIRFOIL. WITH CHANGE IN WIND VELOCITY

at small angles is probably essentially true for full size surfaces moving at speeds of 70 to 100 miles per hour. Similar model tests on a wing of profile B, A. F. 5 give a minimum  $K_R = .00025$  against  $K_L = .00015$  for the double cambered surface. The latter has less than one-half the resistance of the former. For a racing airplane or speed boat which could tolerate a very high leading speed, it might be possible of advantage to use the double cambered profile for the wings as well as for the control.

## Output of Aircraft Under Pressure of War

Prof. Gen. F. G. Stead in *Engineering* argues that experimental work should be carried out under conditions that will test the practicability of quantity output and that in order to secure this, the initial contracts should be let for a lot of a kind (115 machines, all to be built in the same shop). The large figure as double readily applies to present British conditions.







giving maximum Lift/Drag ratio, the lift for upper surface number of 0.98 may be taken as given for a number of 0.05, but the Lift/Drag ratio is diminished by nearly 20 per cent. We shall deal later with the effects of varying the position of the maximum ordinates of the upper surface, the best position for this maximum ordinate is about  $\frac{1}{3}$  of the chord from the leading edge.

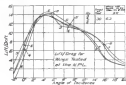


FIG. 5.

#### Complete Data Presented

In Figs. 2 to 6 are given curves for Lift/Drag, Lift/Drag and Center of Pressure action for these wings. In Fig. 6 a comparative table has been drawn up giving maximum Lift coefficient and corresponding angles, maximum L/D and corresponding angles, the angle of incidence and the corresponding L/D for a lift coefficient of value 0.0090, and also the value of  $K_p$  for the tests from which these results have been taken. There is no complete data, as the designer can possibly require. The aspect ratio for all these sections is 6.

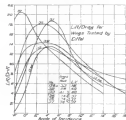


FIG. 3.

We shall deal later with the effects of variation of scale and speed, at this point it is sufficient to state that, whereas the lift coefficient is unaffected by variation in the product (i.e., span of wing in feet times velocity of relative wind in feet per second), the drag coefficient and the L/D ratio are both improved by increase in it. The N. P. L. tests and Eiffel's tests are unfortunately not concordant in this respect. Eiffel's experiments were made in a larger wind tunnel and at higher speeds, and if the same wing were tested in the N. P. L. and Eiffel's laboratory, the latter would give better results for both drag and L/D. There is an actual machine the product (i.e.,

will be very much greater than the value of either laboratory, the full test performance will always be considered below the one so declared from these experimental results, particularly where an S. P. L. section is used. Employing the exact figures of our curves, the designer will be proceeding on a very safe

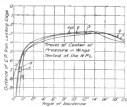


FIG. 4.

margin being. Certain experiments of the S. P. L. in—wind we shall deal with fully later—point us to make approximate corrections. These have been made in the last column of Fig. 6.

#### Points of Interest in Considering a Wing Section

In discussing the results of a series, there are a few points of interest that it is only in an actual design that it is possible to note. Fully into all. Study of the data submitted

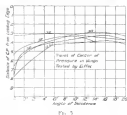


FIG. 5.

will be of much more use if the following features are always kept in mind.

(a) The maximum value of L/D, and the corresponding  $K_p$ , a machine in normal horizontal flight will generally be designed at the angle giving the best L/D ratio, which is therefore most important from an efficiency point of view. The value of the lift coefficient at the best L/D is of importance. The greater the lift of the ratio the smaller the area of the wing surface required for a given load. With a heavy machine, such as a flying boat, or an unusual configuration, a lift coefficient is essential. With a speed boat or a light reconnaissance machine, a small value of  $K_p$  at best L/D is what is needed, so that with a sufficiently powerful motor a small

wing surface may be used and a great speed attained. (b) The maximum  $K_p$  has a bearing on a number of points. The greater the maximum  $K_p$ , the slower is the speed at which a machine may fly and land. If the maximum  $K_p$ , or simply

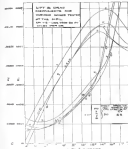


FIG. 6.

large values of  $K_p$ , are accompanied by a good L/D ratio, then the machine will be efficient and truly in other words—though the best scale of climb is by no means the angle of maximum  $K_p$ , as we shall see later in considering the maximum loss of lift.

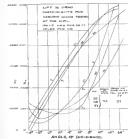


FIG. 7.

(c) The maximum  $K_p$  should occur at as high an angle as possible, so as to give a big range, and possibly of a large climb variation. (d) The angle of maximum lift is termed the bubble point,

as we know, and also the "stall" angle. It is very important to remember what the shape of the lift curve is in the neighborhood of this angle. If the lift past the bubble point falls off very rapidly, the pilot may easily stall the machine. He may increase the angle of incidence too far and find his sustaining power fall off dangerously. A wing with a flat lift curve at the bubble point will arrest such danger.

(e) The L/D ratio at small angles of incidence and small values of  $K_p$  determines whether the machine is really suitable for high speeds. We have arbitrarily chosen  $K_p = 0.0090$  as the value of comparison, and it can be seen from the tables how widely L/D varies at this angle. A machine with good maximum L/D and a high maximum  $K_p$  might be totally inefficient at high speed.

(f) The movement of the center of pressure is important at low angles. If at low angles the center of pressure moves

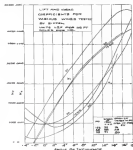


FIG. 8.

slowly back towards the leading edge, the machine will have a tendency to "dive" provided the air is steady, by fixed stabilizing surfaces on leading surfaces. If the center of pressure remains stationary, on the other hand, as in Eiffel's 22, it will maintain its attitude at low angles, and will not tend to dive even with small stabilizing surfaces and constant or increasing clearance. Similar considerations apply to "stall" angles.

(g) In addition to the organic manipulation of these points, there yet remains the appraisal of the wing throughout its performance. The designer must now know for one point of confidence machine with other requirements, what the range is. The ideal wing would give good lift and efficient climb, high efficiency in normal flight, and high efficiency at maximum speeds.

(h) A wing may be entirely satisfactory from an aerodynamic point of view, and yet fail to satisfy as regards structural requirements. In Fig. 9 is shown a typical arrangement of the wing spars. It is important that the points where the wing spars are likely to be placed, the wing should have sufficient thickness to permit the use of reasonably deep spars without overstepped webs. A wing may indeed have sufficient thickness at two points for good spars to be placed, yet these points may be totally unsuitable. They may be too near together so that a weak overlapping construction of spars over spars leading to the result, or too far apart so that too long an unsupported rib section results.

There could be no better place for the reader to whom the







### Aviation Opinions of the Judge Advocate General

**NATIONAL GUARD.**—*Lawrence of pay for aviation service.* The question was presented whether officers and enlisted men of aviation organizations brought into the service of the United States are entitled, while on duty requiring them to participate regularly and frequently in aerial flights, to the increase of pay for such service, the same as provided by statute for officers and enlisted men of the Regular Army.

**Held,** that while the Aviation Section of the Regular Corps, provided for in section 16 of the National Defense Act, is provided for the Regular Army only, and officers and enlisted men of the National Guard are not eligible for detail to all places therein, and while there is no corresponding Regular Corps or Aviation Section provided for the National Guard, there may be Aviation Squadrons, or unit parts thereof, in the National Guard of the several States as component parts of the "complete higher tactical units" contemplated by section 56, ibid., and the officers and enlisted men therein will, when fully qualified, be entitled while in the actual service of the United States, or while attending maneuvers as members ordered by the Secretary at War, to the same pay and allowances as officers and enlisted men of corresponding grades of the Regular Army receive, including increase of pay while on duty requiring them to participate regularly and frequently in aerial flights. (38-201, J. A. G., August 25, 1916.)

#### OFFICERS' RESERVE CORPS

**Held further,** that the Signal Corps (proper) and the Aviation Section (not correct) is a corps which should form the basis of an organization in the Officers' Reserve Corps, the lowest grade in the Signal Corps being that of first lieutenant. As to the Aviation Section, **Held,** that the grade of aviator provided for in section 16 of the National Defense Act, was created as a means of meeting contingencies and supplying casual deficiencies, and should be regarded as temporary and not as a permanent grade or integral part of the Aviation Section, and as should be equivalent to a lieutenant in the Officers' Reserve Corps, but the lowest grade of the Aviation Section in which an unlimited number of officers may be appointed is that of first lieutenant. (38-201, J. A. G., August 25, 1916.)

### Electrical Teletelegraphers for Aeroplanes

A sample instrument termed an electrical telegraphometer, which is likely to be of service, when two operators sit at each of the pilot are employed in heretofore described in *Aeroplane*. This instrument consists of a thin spiral of platinum wire gradually bent in places at the ends of the cable from the motor, connected to a galvanometer, and a small dry battery. The deflections of the galvanometer are a measure of the variation in electrical resistance of the platinum spiral and consequently of the temperature. The platinum spiral is placed in position to be clearly seen by the pilot. Such an instrument should be valuable as a protection against overheating, leakage and so forth. The instrument is an advance of the ordinary type manufactured in Hartmann and Weiss, Frankfurt-am-Main, Germany.

### New Airman 15th Target

That American gunners can hit a target from an aeroplane 2,000 feet in the air almost as well as they can from the deck of a battleship was demonstrated on September 21, when two members of the Aerial Corps from the greater "Lark" Division made nine hits out of twelve shots, according to a "North" report. The firing was done during target practice, the gunners using small arms and bombs.

This is the first experiment of the kind conducted by the Atlantic fleet, and, practically, is one of the fifty-five shots on the Southern drill grounds last observation.

The targets were surrounded by the nature fleet, while the target lines extended around them at various heights. The last shot shooting was from 2,000 feet.

### Aeroplane Radio Signals Sent at Night

Captain C. E. Cohen, U. S. Army, and Lieutenant Herbert Buey are still experimenting with aeroplane radio sets. Recently they have been flying at night at North Island, Calif., for the purpose of transmitting radio signals under the conditions which prevail after dark. There on the field at the army aerodrome are kept burning brightly as reference to the stars where they can find their landing place.



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### A Sperry Night Flying Equipment

A lighting outfit, in addition to full equipment of automatic searchlights, is the latest outfit appliance produced by the Sperry Gyroscope Company. Three 50 megawatt searchlights are attached to a fitting on the upper margin edge of an airplane which intervenes Sperry has been using in night flying experiments at Annapolis, Md., for the past few weeks.

The searchlights are mounted on parabolic reflectors which, as desired, illuminate the megawatt to 50,000 ft. each lamp the fitting, which secures the lamp to the upper plane, is mounted so that it can be tilted in the vertical plane by turning a knob, which is placed within easy reach of the pilot's seat.



SPERRY NIGHT FLYING EQUIPMENT

The device makes signaling with the searchlights a possibility as well as however they are not given power, when the pilot is ready to make his landing. The Morse code can also be used with these searchlights, so the lights themselves are controlled by a switch normally held open by a spring, which can be operated like a telephone key.

The electric current is supplied by a generator of 150-watt capacity, which is driven by the air pressure on an appropriately shaped revolution per minute. Provision is made for any accident to the generator by means of a storage battery, which in case of trouble is automatically thrown into the circuit.

The machine Mr. Sperry has been using is also equipped with the Sperry automatic pilot and gyroscopic drift indicator. A Sperry air compass, mounted by a waterproofed bank, is also part of the equipment.

### IT IS REPORTED THAT—

When Mr. Sperry's file will know a matter of fact (Hugo) has on a record during the summer that is now being set up. On one day he made forty-five flights. His regular routine is flying six to twenty trips a day. He tells a good deal about which means he looks at a few points in his performance as deep as time during a number of times. He flies at an altitude of 500 feet over the sea the location of the Sea can make his decision. It then helps to the help look, where the water is perfectly smooth, land and then clear out to where an airport the Sea. He keeps a notebook to keep the plane from drifting to the left or right and not feel the spirit of looking the way to go on.

E. K. JOHNSON, who has been flying at Atlantic City for the last three years is planning to open an aviation school at St. Augustine for the winter.

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Half-Snell Co. Buys on Government Orders

The Half-Snell Company is manufacturing eight "Big Snell" a week as well as ten of their latest. An order of over 100 of the same is being filled as rapidly as possible. The Dutch East India Government has placed an order for twelve of the "Big Snell" and eight small ones. The Netherlands have purchased eight of the large ones and is awaiting for a much larger order when these are delivered. Three other European governments are using Half-Snell equipment. The United States Navy has purchased twelve "Big Snell," and the Army, twenty-two. Besides this government business, the Half-Snell Company is supplying motors to the following companies: The Standard Aero Corporation, L. H. F., Pacific Aero Products Company, M. F. F., and the Glenn H. Curtiss Company.

#### IT IS REPORTED THAT—

ADJUTANT GENERAL FRANK L. BRIDGES of Indiana is the first State official to try to take advantage of the provisions of the National Defense Act of June 3 to form an aviation corps for the National Guard of his State. He has written to the Indiana troops at Indianapolis, Ind., for applicants who desire to take the six month course in aviation at the State Dugout, Cal. Army School, which the War Department will give its eligible officers from every State.

THOMAS DAVISON, son of H. P. Davison of J. P. Morgan & Co., has ordered a new Curtiss flying boat of 60 horse power similar to those he has been learning to fly during the past summer.

FRANK LEECE, HARBOR S. MARINE, aviation officer, Signal Corps, has returned from duty at the Signal Corps Station, Manila, L. I. N. Y., by an order on September 11, and went to Boston, Mass., for the purpose of taking a post-graduate course in aeronautical engineering at the Massachusetts Institute of Technology.

THE QUINCY CITY AERO PLANE of QUINCY, Ill., is building a monoplane with 70 foot wing spread, 36 foot and six inch, and has 18 horse power model "Pioneer" being driven motor and used for school work among the students as a "project."

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J. E. POTTIER, of Waco, Texas, candidate for Congressional office, according to his own statement, 3,000 in operating an airplane in which he did a large amount of reconnaissance in his campaign for the nomination of the Texas State primary.

BRENN HILMAN received a message from Governor in Lake Washington near Seattle, Wash., a few days ago. S. E. KERRY and Miss Vera Collins were watching him flying boat from a house. The rescue agent, Richard (L. P.) placed in the water and back these boats about the craft where they awaited a boat from shore.

G. T. TAYLOR, the aviator in flying experiments at nearly twice the altitude West. On September 22 and 23 he flew at the Oakland, Calif., Coast.

Two of the new Navy hydroaeroplanes N-1 were satisfactory. Newspaper reports say that they made 60 miles an hour, high speed, and 41 miles an hour low speed.

WILLIAM ELLIOTT, in giving evidence in Schenck, William ELLIOTT was established a training school of aviation and national defense at Indianapolis, Ind. He is a graduate in four three months college graduates under instruction in aviation, who will begin to train in flying November 1. Frederick L. Miles will have charge of the training of the pupils.

GEORGE HAYES died on September 11 at Frederickburg, Tex., as a result of injuries received when he fell while his airplane while going on exhibition at the Gillespie County Fair on that day.

THOMAS W. WATSON are attending the flying school established by the German government just outside Mexico City.

AR. RUTHER, the 22-year-old aviator, who has thrived Chicago, San Francisco and Japan, now never fly in public again. He was up to date in his career in a 65,000,000 plane for the manufacture of airplanes.

THE AMERICAN PLANE AND MOTOR COMPANY has a 160 horse power Sprague dynamometer installed at its plant at Valley, N. J., and can run tests on any one motor up to 160 horse power.

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